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Specific cognitive deficits in tests sensitive to frontal lobe dysfunction in obsessive–compulsive disorder

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SYNOPSIS Forty patients with obsessive–compulsive disorder (OCD) were compared to matched healthy controls on neuropsychological tests which are sensitive to frontal lobe dysfunction. On a computerized version of the Tower of London test of planning, the patients were no different from healthy controls in the accuracy of their solutions. However, when they made a mistake, they spent more time than the controls in generating alternative solutions or checking that the next move would be correct. The results suggest that OCD patients have a selective deficit in generating alternative strategies when they make a mistake. In a separate attentional set-shifting task, OCD patients were impaired in a simple discrimination learning task and showed a continuous cumulative increase in the number who failed at each stage of the task, including the crucial extra-dimensional set shifting stage. This suggests that OCD patients show deficits in both acquiring and maintaining cognitive sets.

The cognitive deficits in OCD may be summarized as: (i) being easily distracted by other competing stimuli; (ii) excessive monitoring and checking of the response to ensure a mistake does not occur; and (iii) when a mistake does occur, being more rigid at setting aside the main goal and planning the necessary subgoals. Both studies support the evidence of fronto-striatal dysfunction in OCD and the results are discussed in terms of an impaired Supervisory Attentional System.

INTRODUCTION

The core psychiatric symptomatology in obsessive–compulsive disorder (OCD) has been suggested to be subserved by neural loops connecting the basal ganglia and frontal lobes (Alexander *et al.* 1986; Wise & Rapaport, 1989; Baxter *et al.* 1991). Computerized Axial Tomography (CAT) studies suggest that the volume of the caudate nucleus is decreased in OCD patients compared with healthy controls (Luxenberg *et al.* 1988; Robinson *et al.* 1995). Positron Emission Tomography (PET) studies report hypermetabolism in the frontal orbital cortex of patients with OCD (Baxter *et al.* 1988; Nordahl *et al.* 1989; Swedo *et al.* 1989; Sawle *et al.* 1991). In addition, two studies found hypermetabolism in the caudate nucleus (Baxter *et al.* 1988, 1989) and one found hypermetabolism in the pre-motor and mid-frontal cortex in patients with obsessional slowness (Sawle *et al.* 1991).

Clinically, OCD patients exhibit slowness in thinking, a symptom that may occur directly as a result of bradyphrenia (Hymas *et al.* 1991) or indirectly as a consequence of their avoidance behaviour, orderliness and meticulousness (Veale, 1993). However, to date, no study has sought to differentiate between these two possibilities. The most consistent findings on previous neuropsychological testing in OCD patients are lowered scores on visuo-spatial tasks (Flor-Henry *et al.* 1979; Behar *et al.* 1984; Head *et al.* 1989; Boone *et al.* 1991; Zielinski *et al.* 1991). These results may be related to basal ganglia dysfunction as visuo-spatial defects are also associated with basal ganglia lesions (Boller *et al.* 1984). The results of tests on executive function in OCD patients have been inconsistent and difficult to interpret. Four studies have found no impairment in OCD on two classic

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tests of frontal lobe function – the Wisconsin Card Sorting Test (WCST) (Cox *et al.* 1989; Boone *et al.* 1991; Zielinski *et al.* 1991) and verbal fluency (Zielinski *et al.* 1991). One study has reported significant increases in perseverative errors on the WCST but not on verbal fluency (Head *et al.* 1989). The WCST is one of the most widely used tests of executive function but is criticized as involving many different cognitive processes (Downes *et al.* 1989), including concept formation, shifting and matching-to-sample. A deficit may result from a failure to coordinate these different requirements for successful performance, or alternatively, from an impairment in a component that may not involve the frontal cortex at all. Thus, the WCST also requires visuo-spatial processes that may be compromised in patients with OCD (Head *et al.* 1989; Boone *et al.* 1991).

In recent years, a number of new tests have been developed to investigate, more precisely, the role of the frontal lobes in normal cognitive functioning. For example Shallice & McCarthy (see Shallice, 1982) developed the Tower of London task, a series of problems which depend more heavily on planning than on visuo-spatial processing abilities. Performance on this test can be broken down into a number of independent components relating to accuracy or speed of problem solving. We used the computerized CANTAB Tower of London task which has the advantage of being able to record latencies, and therefore provides accurate measures of both the subject's time spent in thinking and in responding. We also used the CANTAB computerized attentional set shifting task that is analogous, in some respects, to the WCST but which provides a 'purer' test of set-shifting ability and removes the need to perform the matching-to-sample element that complicates the WCST.

The aim of the present study was, therefore, to assess a group of OCD patients for: (i) any neuropsychological evidence of slowness in thinking such as that which has been reported previously in other fronto-striatal disorders including Parkinson's disease (Morris *et al.* 1988; Owen *et al.* 1992) and in neurosurgical patients with frontal lobe excisions (Owen *et al.*, 1990); or, (ii) deficits in specific executive functions such as spatial planning as assessed by the Tower of London task and increased distractibility and perseveration as assessed by the attentional set shifting task.

It was hypothesized that OCD patients would be impaired in their ability to plan solutions to the Tower of London problems and in terms of the amount of thinking time required to produce these solutions. In addition, it was predicted that deficits would be observed in their ability to maintain attention and shift set in the attentional set-shifting task. Finally, it was hypothesized that patients with an additional diagnosis of obsessive compulsive personality disorder would have increased latency measures because of their meticulousness, perfectionism and indecisiveness.

METHOD

Subjects were in-patients in the behaviour therapy unit at the Bethlem Royal Hospital or out-patients at the Maudsley Hospital. The control group of healthy volunteers were medical and ancillary staff at the Maudsley Hospital. Subjects in both groups had to be aged between 18 to 65 but could be of either sex. All patients had to fulfil the DMS-III-R (APA, 1987) criteria for obsessive–compulsive disorder (OCD). Subjects were excluded from the study if they had either: (i) fears of contamination (such as dust or radiation) from the computer screen on which they would be tested; or, (ii) predominantly obsessive thoughts or ruminations that might interfere with the neuropsychological testing.

Each patient was screened by a clinical interview to exclude a major depression or other psychiatric disorder. All patients completed the Compulsive Activity Check List (CACL) (Marks, 1986) and were interviewed with the relevant questions for the diagnosis of Compulsive Personality Disorder from the Structured Interview for DSM-III-R Personality Disorders. None of the patients had any other relevant co-morbid conditions such as tics or Tourette's syndrome.

Pre-morbid verbal IQ was estimated from the National Adult Reading Test (NART) (Nelson, 1982). The verbal IQ of each patient was pro-rated from the Vocabulary and Comprehension subtests of the Revised version of the Wechsler Adult Intelligence Scale (WAIS-R) (Wechsler, 1981).

Subjects were assessed, as follows, on two tests from the Cambridge Neuropsychological Test Automated Battery (CANTAB).

(*i*) *The Tower of London Task*

This task tests spatial planning and a full description can be found in Owen *et al.* (1990). In brief, two sets of three coloured balls are presented on a touch sensitive computer screen, one in the top half of the screen and one in the bottom half. These were described as 'snooker balls' since they appeared to be hanging in pockets or 'socks'. On each trial, a red ball, a blue ball and a green ball were placed in predetermined positions in the pockets of the two displays. Subjects are asked to examine the position of the balls at the beginning of each problem and attempt to copy the pattern in the top half of the screen by rearranging the balls in the bottom half in the minimum number of moves necessary. A 'perfect' solution is one that was completed by the subject in the minimum number of moves possible. A ball could be moved by first touching it and then touching an empty position in one of the other pockets. The starting position of the balls was varied such that in any particular trial, the solution could only be reached after a minimum of two, three, four or five moves. Subjects were informed how many moves were required to complete the match and to attempt to solve it in the minimum possible number of moves. Subjects were therefore aware when they did not complete a 'perfect' solution; that is, in the optimum number of moves. For each problem a 'yoked control' condition was employed to provide baseline measures of motor initiation and execution times. On each trial of this control condition, the subject was required to follow a sequence of single moves executed by the computer in the top half of the screen by moving the corresponding ball in the lower arrangement. Thus, initially the two arrangements differed by just one ball. Once the subject had made the appropriate move, the top arrangement changed again so the subject had to make another single move. The test was 'yoked' to the main test in the sense that in each trial, the movement of the balls was an exact replication of those moved by the subject in the corresponding test trial. The measurement of the selection and execution latencies in the control condition provided baseline estimates of the motor initiation and execution times. The movement times were used to derive estimates of planning or 'thinking' time in the main task. In each problem, the initial thinking time was the time between the initial presentation of the problem and the first touch, minus the corresponding motor initiation time as calculated from the yoked control task. The subsequent thinking time was the time between the selection of the first ball and the completion of the problem minus the total motor execution time derived from the corresponding problem.

(*ii*) *The attentional set-shifting task*

This tests the ability to attend to specific dimensions of compound stimuli and to shift attention when required and a full description can be found in Downes *et al.* (1989). In brief, the task requires subjects to learn a series of two-alternative forced-choice discriminations using the immediate feedback provided automatically by the computer. The learning criterion is six consecutive correct responses. The task is composed of nine stages presented in the same fixed order, starting with a simple discrimination (SD) and its reversal (SDR) for stimuli varying in just one dimension (e.g. two different white line configurations). A second, alternative dimension is then introduced (purple filled shapes) and compound discrimination (CD) and reversal (CDR) are tested.

To succeed, subjects must continue to respond to the previously relevant dimension while ignoring the presence of the new, irrelevant dimension. At the intradimensional shift stage (IDS), novel exemplars of each of the two dimensions are introduced and subjects must continue to respond to one of the two exemplars from the previously relevant dimension. Following another reversal (IDR), the extra-dimensional shift (EDS) and its reversal (EDR) are presented, again using novel exemplars of each stimulus dimension. In order to succeed at this stage, the subject must shift 'response set' to the previously irrelevant stimulus dimension, while ignoring the previously relevant dimension. The EDS stage is akin to a change in category in the Wisconsin Card Sorting Test. The main measure of performance on this task was the stage successfully attained.

Statistical analysis

The data was analysed using the Statistical Package for Social Sciences (SPSS-PC) (Nie *et al.* 1970). Age and verbal IQ if the two groups was compared by a one-way analysis of variance (ANOVA). Sex distribution was analysed by a chi-square test. Data from the Tower of London task were compared by ANOVA with a repeated measures design with two factors – a between-subjects factor (group) and a within-subjects factor (difficulty level). The likelihood ratio method of contingency tables ('the information statistic') (Kullback, 1968; Robbins, 1977) was used for the small cell frequency in the attentional set shifting task. The Pearson product moment correlation coefficient (Winer, 1971) was used to assess the relationship between the severity of the symptoms of OCD and scores on the Tower of London task.

RESULTS

Forty-nine patients were recruited of whom nine were excluded. One was excluded because of a fear of contamination from the radiation of the computer screen; two because of a fear of contamination from dust on the computer screen; six had a major depression. These nine subjects did not participate further and no data was recorded for them.

(i) Tower of London task

There were 40 patients with OCD and 22 healthy controls for comparison. The two groups were well matched regarding mean age and mean verbal IQ (Table 1). Mean scores on the Compulsive Activity Check List was 35·1 (S.E. = 2·55).

In the Tower of London test, there was no significant impairment on any of the measures of accuracy in solving the problems. Thus, there was no difference in the mean number of excess moves that the patients took to solve the problems (F (1, 62) = 1·33, P = 0·25). Both patients and controls solved the same proportion of problems in the minimum number of moves possible (F(1, 62) = 0·27, P = 0·61). Both groups solved the same proportion of problems in the maximum number of moves permissible (F (1, 62) = 1·57, P = 0·22). This suggests that regardless of the measure of accuracy, the patient groups were unimpaired. For all of the analyses above there was a significant main effect in terms of task difficulty (i.e. whether the problem required 2, 3, 4 or 5 moves to the solution) but no interaction between the group and difficulty factors. For latency measures, there was no difference between patients and controls in the initial thinking time when all solutions were considered (F(1, 61) = 1·31, P = 0·26) (Table 2). The groups differed significantly, however, when solutions not completed in the minimum number of moves (termed 'imperfect solutions') only were considered (F (1, 59) = 11·45, P = 0·001) but not when the analysis included only perfect solutions (F, (1, 61) = 2·77, P = 0·10) (Table 3). OCD patients were significantly slower than controls in terms of their subsequent thinking time when all the problems were considered (F (1, 61) = 8·33, P < 0·005) (Fig. 1, Table 4) and

Table 1. *Clinical characteristics of subjects in the Tower of London task*

	OCD patients	Controls
Number	40	22
Age	36·10	32·23
(S.E.)	(1·76)	(2·21)
% Male	42·5	68
NART Verbal IQ	109·9	109·2
(S.E.)	(1·62)	(1·87)

Table 2. *Initial thinking times in seconds in the Tower of London task (mean/S.E.)*

Difficulty of problem	Patients	Controls
2 move	2·94 (0·59)	2·72 (0·60)
3 move	11·94 (1·87)	6·94 (1·17)
4 move	12·32 (1·70)	9·53 (1·52)
5 move	14·58 (2·39)	14·12 (3·26)

Table 3. *Initial thinking time in seconds for perfect move solutions only in the Tower of London task (mean/S.E.)*

Difficulty of problem	Patients	Controls
2 move	2·94 (0·59)	2·74 (0·60)
3 move	9·66 (1·16)	6·88 (1·18)
4 move	12·15 (1·69)	8·47 (1·37)
5 move	14·78 (2·43)	10·26 (1·68)

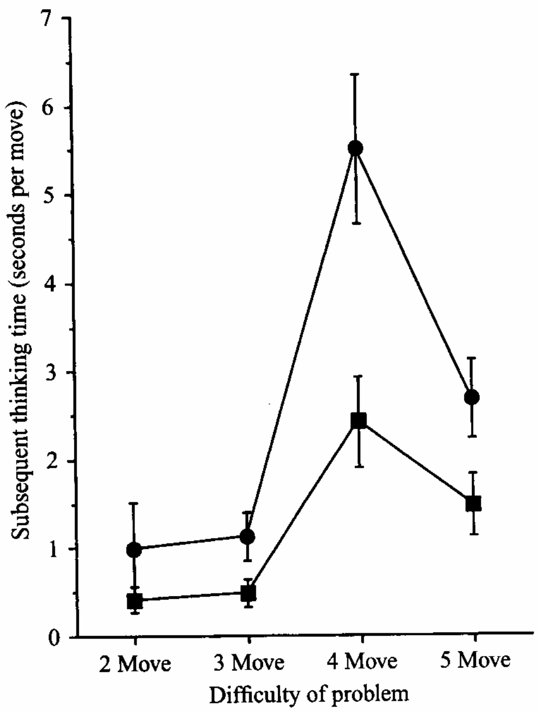

FIG. 1. Mean subsequent thinking time in the Tower of London task for patients (●) and controls (■).

Table 4. *Subsequent thinking time in seconds per move in the Tower of London task (mean/S.E.)*

Difficulty of problem	Patients	Controls
2 move	0·98 (0·52)	0·41 (0·14)
3 move	1·13 (0·27)	0·49 (0·15)
4 move	5·51 (0·84)	2·41 (0·51)
5 move	2·67 (0·45)	1·47 (0·35)

Table 5. *Subsequent thinking time in seconds per move for perfect move solutions in the Tower of London task (mean/S.E.)*

Difficulty of problem	Patients	Controls
2 move	0·99 (0·52)	0·41 (0·14)
3 move	0·46 (0·47)	0·47 (0·15)
4 move	1·52 (0·38)	1·33 (0·46)
5 move	0·83 (0·26)	0·87 (0·34)

when imperfect solutions only were considered ($F(1, 59) = 4·93, P < 0·03$). However, for perfect move solutions, OCD patients and controls did not differ in subsequent thinking time ($F(1, 61) = 0·21$, $P = 0·65$) (Table 5).

There was no difference in the initial movement time between patients and controls ($F(1, 61) = 2·18$, $P = 0·14$), but the patients were significantly slower in their subsequent movement time when all problems were considered ($F(1, 61) = 5·19$, $P < 0·026$).

Next, the patient group was divided into those with obsessive–compulsive personality disorder (OCPD) ($N = 15$) and those without ($N = 25$). There was no difference in age ($F(2, 62) = 1·66$, $P = 0·19$), sex ($\chi^2 = 4·87$, $P = 0·08$) or verbal IQ ($F(2, 62) = 0·25$, $P = 0·8$). The presence of OCPD made no difference to the results when the two patients groups were re-analysed separately. For the patient group as a whole, there was no correlation between the severity of OCD symptoms (as measured by the OCD checklist) or any other measures. Eight patients were on anti-depressants. There were no differences on any of the analyses between these eight patients and the 32 patients who were not on anti-depressants.

Table 6. *Clinical characteristics of patients and controls in the attentional set-shifting task*

	OCD patients	Controls
Number	40	36
Mean age	36·1	32·3
(S.E.)	(1·76)	(1·27)
% Male	42·5	44·4
Mean NART IQ	109·9	110·0
(S.E.)	(1·62)	(1·2)

(ii) Attentional set-shifting task

There were 40 OCD patients and 36 subjects in the control group. The patients were the same ones who performed the Tower of London task. The control group was made up of 14 of the same control volunteers who performed the Tower of London task and 22 new subjects. There was no difference between the patients and controls in mean age ($F(1, 76) = 2·20$, $P = 0·14$), mean verbal IQ ($F(1,76) = 0·28$, $P = 0·59$), or sex distribution ($\chi^2 = 0·0$, $P = 1·0$) (Table 6).

They were compared on the proportion of subjects reaching criterion (six consecutive correct responses) within the 50 trials allowed at each of the nine stages of the test. The number of patients who failed at each stage was analysed cumulatively. As the test became harder, the analysis assumed that if a subject failed an

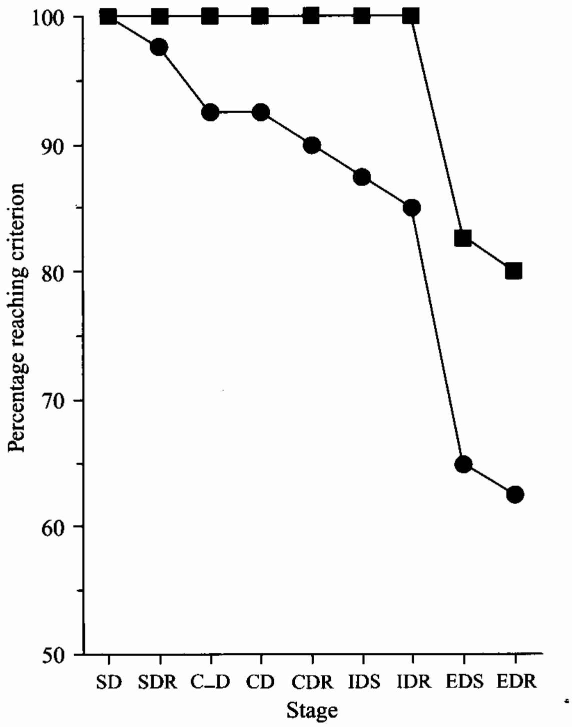

FIG. 2. Percentage reaching criterion at each stage for Attentional Set Shifting task for patients (●) and controls (■).

Table 7. *Trials to criterion at IDS and EDS stages in the attentional set-shifting task*

	OCD patients	Controls
IDS mean	14·83	7·45
(S.E.)	(2·23)	(0·41)
One-way ANOVA *F*-ratio (1, 62) = 5·9, *P* = 0·018*		
EDS mean	29·87	18·89
(S.E.)	(2·84)	(2·5)
One-way ANOVA *F*-ratio (1, 62) = 3·38 *P* = 0·05*		

earlier stage then he or she would fail at a later stage. The data were analysed by the likelihood ratio method of contingency tables (Kullback, 1968; Robbins, 1977). Compared with controls, there is a steady cumulative increase in the number of patients who fail at each stage of the task (Fig. 2) (significant at the C_D stage (2i = 3·9, $P < 0{\cdot}05$) and at all subsequent stages). When only those subjects who actually attempted each stage were analysed, there was no significant difference at any stage. There was thus a gradual decline in the performance of the patient group that was only significant when the data are analysed cumulatively. Analysis was then focused on the two critical ID and ED shift stages to test for differences between groups on any measure for subjects reaching those stages. The performance of the two groups on the ID and ED shift was analysed according to the number of trials required to reach the criterion at each of these stages. The OCD patients took more trials to reach the criterion, a pattern which was significant at the IDS stage (F (1, 62) = 5·9, $P < 0{\cdot}018$) and at the EDS stage (F(1, 62) = 3·88, $P < 0{\cdot}05$) (Table 7). The groups did not differ in their mean latency per trial to respond at the IDS stage (F (1, 58) = 1·81, $P = 0{\cdot}18$) or at the EDS stage (F (1, 56) = 2·73, $P = 0{\cdot}10$) (Table 8).

Separation of the patient group according to the presence of OCPD produced two groups who were matched according to age, verbal IQ and sex. There were no major differences to the results of the contingency analyses except that the C_D, CD, CDR stages on the cumulative analyses were no longer significant. Patients (with or without OCPD) took more trials than controls to reach the criterion at the IDS stage (F (2, 62) = 3·21, $P < 0{\cdot}047$) although not at the EDS stage (F (2, 62) = 1·91, $P = 0{\cdot}16$).

The data for patients on the attentional set-shifting task were split into two subgroups: (i) those completing the whole task ('ED pass' subgroup, $N = 25$); and, (ii) those failing at or before the final EDR stage ('ED fail' subgroup, $N = 15$) to determine whether those patients who performed poorly on the attentional set-shifting task also performed poorly on the Tower of London task. The two patient groups were, therefore, compared against the control group in the Tower of London task. Full details of this sub-analyses are provided in Veale (1995). There was no difference between the two subgroups in the demographic data, NART Verbal IQ, or Compulsive Activity Check List. There was, however, a significant difference between the

Table 8. *Latency in seconds at IDS and EDS stages of the attentional set-shifting task*

	OCD patients	Controls
IDS mean	1·99	1·43
(S.E.)	(0·11)	(0·07)
One-way ANOVA *F*-ratio (1, 58) = 1·81 *P* < 0·05		
EDS mean	2·21	2·18
(S.E.)	(0·19)	(0·21)
One-way ANOVA *F*-ratio (1, 56) = 2·73 *P* < 0·05		

three groups in terms of Tower of London accuracy as the 'ED fail' subgroup was significantly poorer compared to controls, while the 'ED pass' subgroup was not. There was no difference between either patient group and the controls on any measure of initial thinking time. The subsequent thinking time was significantly impaired in both subgroups when all problems were considered. In summary, the analysis suggests that OCD patients who pass the attentional set-shifting task ('ED pass') perform rather like the OCD group as a whole on the Tower of London task in that subsequent thinking time was particularly impaired when all the solutions were considered. However, the 'ED fail' subgroup also perform poorly on the Tower of London task in terms of the accuracy of their solutions.

DISCUSSION

OCD patients showed a characteristic pattern of cognitive deficits on tests sensitive to frontal lobe dysfunction. When OCD patients made a mistake on the Tower of London planning task, they spent more time generating alternative solutions and were impaired in their ability to plan an alternative subgoal to reach the final solution. In the attentional set shifting task, OCD patients were impaired in discrimination learning and reversal and at the critical intra-dimensional and extradimensional stages of the task. Again, this pattern of findings may reflect an impairment in the ability to generate alternative strategies following an incorrect response. The results suggest that OCD patients show deficits in both acquiring and maintaining cognitive sets. A motivational explanation for these results is unlikely, since the profile of impairment in depression does not resemble that of OCD (Beats *et al.* 1996; Elliott *et al.* 1996).

The planning component of the Tower of London task is related to the difficulty of the task as hypothesized by Shallice (1982). Thus when the problems require two or three moves, the requirements for planning are minor and do not require programming of several complex subgoals. When the task is increased to four or five move solutions, the planning component increases. Since patients with OCD managed to solve the Tower of London problems accurately (and therefore generate, refine, and revise solutions) the findings of the present study argue against any deficit in the programming of accurate sequences of responses *per se*. When OCD patients make a mistake, however, they take more time to reach the solution (even though they reach it in the same number of moves as the controls). OCD patients are, therefore, as accurate as healthy controls, but when they make an incorrect move, they are slower at generating alternative strategies. One explanation for this pattern of findings is that when a mistake occurs, OCD patients become more rigid at setting aside the main goal and planning the necessary subgoals to complete problems. An alternative, but not mutually exclusive explanation is that when OCD patients do make a mistake, they are just as fast as controls in generating an alternative strategy, but spend more time *checking* that it will indeed lead to a correct solution. This latter possibility may seem less likely since there was no difference between patients with, or without, OCPD and one might reasonably expect patients with OCPD to show an increased thinking time because of their perfectionism and meticulousness. However, the diagnosis of OCPD is made on a number of different constructs so that some patients with OCPD may not necessarily be perfectionists or show more meticulousness.

Patients may thus be trying too hard to monitor their responses to ensure that they do not make a mistake. Monitoring is one component of executive function (Petrides, 1994), which refers to a variety of high-level cognitive processes including planning, abstract reasoning and decision making. Although executive function is considered to depend critically upon on the function of the prefrontal cortex, it is important to note that the term executive function is a psychological construct and as such has no localizing value. The explanation of excessive monitoring in the OCD group is, however, consistent with the results of PET studies that report hypermetabolism in the frontal orbital cortex in patients with OCD (Baxter *et al.* 1988; Nordhal *et al.* 1989; Swedo *et al.* 1989; Sawle *et al.* 1991) and with the cognitive therapy model of OCD in which patients are construed as trying too hard to exert control over normal mental processes and activity in a variety of counter-productive and anxiety-provoking ways (Salkovskis *et al.* 1995).

In the attentional set shifting task, patients were significantly impaired in their ability to shift set and maintain attention in a simple discrimination task. Compared to controls, there is a steady decline in the number of patients who pass at each stage of the attentional set-shifting task as well as at the crucial extradimensional shift stage. A successful extradimensional shifting performance is assumed to depend on the integrity of the frontostriatal pathways (Downes *et al.* 1989; Sahakian *et al.* 1990) and this has been formally tested in studies using non-human primates (Roberts *et al.* 1991; Dias *et al.* 1996). The results of the present study suggest that OCD patients were impaired at selectively attending to the relevant dimension when a second distracting dimension was introduced and in the maintenance of an attentional set at the intradimensional shift stage. Thus, OCD patients are easily distracted by other competing stimuli, which are quickly ignored by healthy controls. Therefore, it may be that OCD patients are less efficient at encoding relevant feedback, and by checking excessively are collecting too much irrelevant data in working memory. Hence, problems of generating and checking responses may provide an explanation for both sets of results. This phenomenon is likely to be exaggerated by anxiety and, clinically, this may manifest itself as obsessional doubting which occurs for example when subjects are unable to confirm whether their checking or washing is sufficient to prevent a specific danger.

Increased distractibility and perseveration may occur as a result of diminished supervisory frontal lobe influence (Robbins & Sahakian, 1983). The results are consistent with the hypothesis of Norman & Shallice (1980), which states that in the functional absence of a Supervisory Attentional System, action schemas are triggered directly by environmental stimuli (leading to increased distractibility and loss of behavioural control) or by current activity leading to response perseveration and difficulty in shifting mental set. This 'stuck-in' set perseveration is a continued use of a framework that has become inappropriate due to a frontal dysfunction and a failure of the central executive (Sandson & Albert, 1984). Compulsions are an example of perseverative behaviour in which the frontal lobe may be unable to inhibit the motor or cognitive programmes of the basal ganglia. Although the pattern of impairment in the OCD group appeared to be specific, a subgroup of patients who perform poorly on the attentional set-shifting task were also impaired in terms of accuracy on the Tower of London test. In this sense, this 'ED fail' subgroup shows even greater frontal dysfunction than the 'ED pass' subgroup and actually resemble neurosurgical patients with frontal lobe excisions (Owen *et al.* 1990).

In summary, the profiles of cognitive impairment seen on these tests of executive function appear to be unique and specific to OCD, as it is not seen in other relevant patient groups, including those with depression (Beats *et al.* 1996; Elliott *et al.* 1996); the fronto-subcortical dementia of Parkinson's disease (Downes *et al.* 1989; Owen *et al.* 1990) or the classic posterior cortical dementia of Alzheimer's disease (Sahakian *et al.* 1990).

The cognitive deficits in OCD and slowness in thinking may thus be summarized as problems of: (i) being easily distracted by other competing stimuli (both internal and external); (ii) excessive monitoring and checking of the response to ensure a mistake does not occur; and (iii) when a mistake does occur, being more rigid at setting aside the main goal and planning the necessary subgoals.

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